EMP Simulation and Measurement Data Analysis in Support of the Titan Experiments

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Electromagnetic pulse (EMP) is a known issue for a variety of situations including short-pulse laser facilities such as LLNL's Titan and Omega, and experts believe EMP will also be an issue with NIF. During FY2007, this project focused on improving simulation capabilities of EM fields due to electrons from laser/target interactions, and providing post-processing algorithms and software.

Project Goals

The overarching goal of this project is to simulate EMP in situations like the Titan short-pulse laser due to electrons from laser/target interactions and to compare measurement results with the simulations. To accomplish the simulation task, we used EMSolve 3, an LLNL EM solver. Unlike most available codes, EMSolve's architecture allows seamless integration of user-created sources and boundary conditions, and EMSolve has been augmented with electron beam sources.

Relevance to LLNL Mission

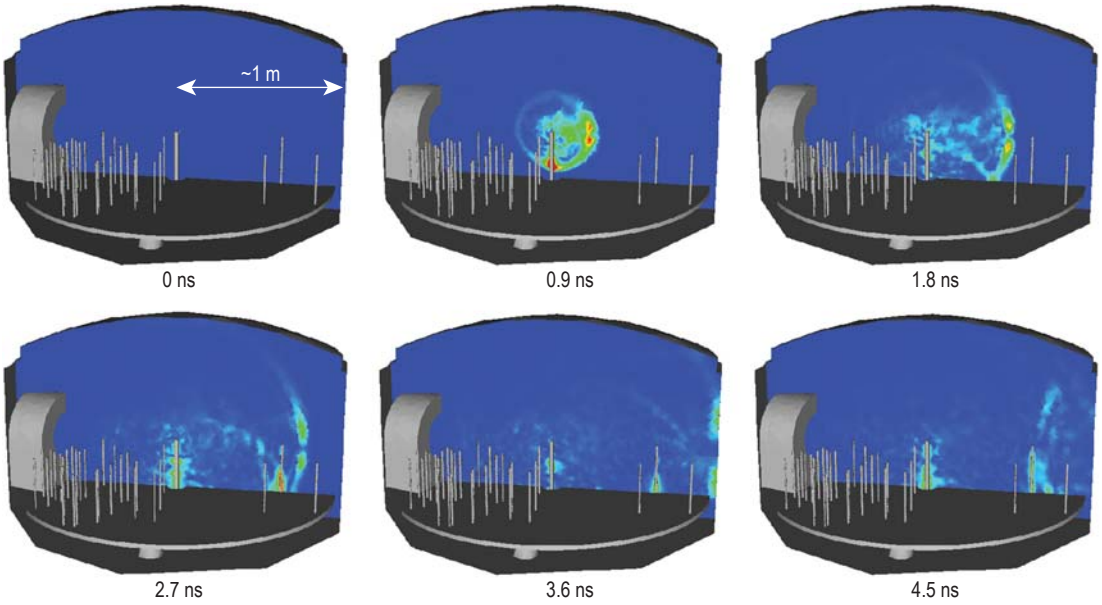
An understanding of the EMP in Titan, through the simulation and analysis in this project, will be extrapolated to NIF and other short-pulse lasers around the world to better mitigate EMP effects.

FY2007 Accomplishments and Results

During FY2007, we gained further experience in performing simulations using the EMSolve processing chain, which consists of Cubit, EMSolve, and VisIt. Cubit is a meshing tool from Sandia National Laboratories that is used to construct models for EMSolve. VisIt is an LLNL code for visualizing simulation data.

We created more realistic CAD models of the Titan chamber, including finer details such as optics stands modeled as rods. Further, we augmented EMSolve so that both the magnetic and electric fields of electron beam sources can be simulated accurately. We also advanced our ability to post-process data measured by B- and D-dot probes, in particular deconvolution of the probe response.

The deconvolution method we used is an optimal method based on the Wiener filter, which is implemented in processing software. We have extended the software tool and created a user



Time sequence of simulation of magnetic field due to propagating electron bunch.

interface called Time-Series Analysis Tool (TSAT) that allows quick and easy manipulation of time-series data and includes data input, signal processing, and display capabilities. The simulation and post-processing capabilities originating from this project have allowed us recently to publish a comparison of a simulation of an electron beam in Titan and actual, measured data.

The figure depicts frames of a time sequence of the magnetic fields due to 10^{12} electrons in a Gaussian bunch with a full-width at half maximum of 100 ps.

Related References

1. Mead, M. J., *et al.* "Electromagnetic Pulse Generation within a Petawatt Laser Target Chamber," *Review of Scientific Instruments*, **75**, 10, pp. 4225-4227, October 2004.
2. "VisIt Visualization Tool," http://www.llnl.gov/VisIt/home.html.
3. Candy, J. V., Model-Based Signal Processing, Wiley-IEEE Press, 2006.
4. Brown, C. G., Jr., *et al.*, "Electromagnetic Pulses at Short-Pulse Laser Facilities," *Proceedings of the 5th International Conference on Inertial Fusion Sciences and Applications*, Kobe, Japan, September 9-14, 2007.

FY2008 Proposed Work

Our FY2008 work will include improving our CAD models to perform more realistic simulations; continuing to perform EMSolve simulations; assisting the experimental team in the measurement process to better understand the measurement system; and working with signal processing experts to calibrate and analyze the data, particularly the data obtained from the September 2007 dedicated shots in Titan.